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Abstract

An exploratory study using dual target presentation of peripheral visual acuity targets for school aged children was undertaken. Children in the second (N=8), fourth (N=11), and sixth (N=9) grades were presented with acuity levels of 20/1300, 20/650, 20/325, and 20/162 at three angular separations of 32, 25, and 17 degrees to the right eye only. A trend was found for increased recognition error with each decreasing acuity size with increasing angular separation. When only one target of the pair was reported correctly, the nasal field target was identified correctly more often than the temporal field by a ratio in excess of 4 to 1. Suggestions for a more effective experiment were offered.

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REVIEW OF LITERATURE

Peripheral visual acuity has been discussed and reviewed since ancient times. Reliable interest and experimentation concerning the peripheral visual system has existed since 1894 when first carefully determined the relative progressive decline of acuity from fovea to periphery (Low, 1951[1]; Kerr, 1971[2]). The many different investigators have chosen to use various definitions of visual acuity in their measurements and as a result there are as many standards and comparisons of peripheral visual acuity as there are investigators.

Among the latest classical studies in this area are Low (1943a[3], 1943b[4]). In his report of very precise and extensive research, Low examined the temporal periphery from 30 to 90 degrees eccentric at a distance of 25 centimeters under photopic conditions, the variation of peripheral visual acuity among individuals was found to be even greater than anticipated. For this reason, among others, there has been a great diversity of accepted acuity values in the periphery; however, many other characteristics concerning the peripheral visual system were explored. This variation of the acuity for any point increased as the acuity itself decreased. The relative average acuity for each point agreed in shape with Wertheim's, however Low used Landolt C targets and Wertheim's results were obtained with a grating target. Additionally, Low showed that central acuity was not a reliable indicator or peripheral visual acuity. Peripheral vision failed to decline with advancing age (17 to 40 years) where central vision declined due to lens changes.

In a major review by Low (1951[1]), many of the factors affecting peripheral visual acuity were discussed and are briefly mentioned here. Expectedly, as angular eccentricity increased visual acuity decreased and temporal horizontal acuites were about twice as strong as vertical acuities. The differences between temporal and nasal horizontal meridians were of a lesser order. Different test objects provided different kinds of acuities which had the same shape but the diversity increased disproportionately with increased peripheral deviation. Brightness effects are still widely discussed, however, Low reported a negligible difference between photopic and scotopic illumination levels beyond 30 degrees of temporal field eccentricity. Additional studies in this area include: Mandelbaum & Sloan, 1947[5]; Zahn & Haines, 1971[6]; Kerr, 1971[2]; Aspinall, 1976[7]; and Whiteside, 1976[8]. Color of test object was not a significant determinant of peripheral acuity. Neither sex nor age appeared to show consistent differences in the relative acuity. Moving peripheral measurements were more sensitive than stationary simple form acuities. Low found a decrease in acuity with decreased exposure time, whereas Clemmesen(1944[9]) obtained opposite results. The majority of current studies utilize limited viewing time to control for eye movements. As with many experimental situations, various psychological factors including attention and spontaneous fluctuations affect the measurements made on the human eye. Of great importance was the observation that peripheral acuity seemed to be highly trainable. Improvement was transferred to unfamiliar test objects, unpracticed retinal areas, limited viewing time, night visual acuity, and non-laboratory everyday life. As all of the above factors may influence the peripheral acuity it was concluded by Low, that the individual variability among a group of subjects was the most likely source of discrepancy.

An additional point made by Low may be applied to all reviews of literature in this area, in that, peripheral acuity is often expressed as relative acuity or rather as a fractional value of the central acuity. When relative acuity is plotted there is an initial drastic decrease and a much slower drop in the periphery. Actually, the initial decrease is observed to be gradual with a definite tendency toward a more rapid loss in the periphery when expressed as resolution in minutes of arc.

Another of the classical determinations of the characteristics of the peripheral visual system was accomplished by Mandelbaum & Sloan (1947[5]). Again using Landolt C's as the target only now at three distances: 2,4, and 8-10 meters (depending on the acuity level). Exposure time was 200 milli seconds at up to 30 degrees eccentricity. The independent variable was the luminance at which threshold was reached. Conclusions based on this study were : (1) scotopic peripheral acuity did not parallel the rod population or light sensitivity or the retina; (2) light intensity was not a critical factor in peripheral acuity as it was in central acuity; (3) 25 to 30 degrees eccentric, the rod cells dominate form discrimination even at higher intensity levels.

Other studies of the quantitative decrement of visual acuity in the periphery include the work of Feinberg (1949[10]). An excellent literature review again indicates the persistent consideration of peripheral visual acuity throughout many years. In contrast to previous studies the testing distance was twenty feet. Again Landolt C's exposed at 180 milliseconds under photopic conditions were displayed at eccentricities of 1 to 5 degrees. Conclusions reached as a result of this distance peripheral acuity measurement were similar to Low's. There was an increased similarity of the peripheral visual acuity thresholds regardless of meridional positions as the targets were moved away from the center. Meridional positions compared to each other exhibited slight but apparently insignificant differences. There was little correlation between central and peripheral visual acuities, and again individual differences in maintaining levels of peripheral acuities were pronounced.

As discussed by Feinberg, many studies have utilized the Landolt C as a target because it fulfilled the requirements of being unlearnable, constant in form, and the total angular width was reduced to a minimum in comparison to other targets.

Other excellent surveys of literature include LeGrand (1967[11]), where he pointed out that without changing eye position, one can shift attention in the visual field. Further research in this attention area has been carried on by Bartz (1976[12]); Beck & Ambler (1973[13]); and Grindley & Townsend (1968[14]). In reaction time experimentation, Bartz found that an increasing information load of the central task served to heighten the subject's arousal level and resulted in shorter reaction times to peripheral visual signals. Beck & Ambler explained that due to parallel storage and retrival of visual information, information about discriminable simple properties may be read out in parallel more quickly than information about less discriminable or relational properties. Actually they concluded that attention speeds up getting it in rather than processing to readout. In contrast, Grindley & Townsend suggested that the role of attention in peripheral vision was to ensure that when there were competing messages from other parts of the visual field, the messages from the part to which attention was directed (most likely the contral stimuli) was given priority of treatment.

Many sophisticated studies involving the determination of peripheral resolution have been completed in the last eight years. Most of these have compared the visual acuity of the peripheral retina as measured by sinusoidal gratings viewed in space with interference fringes formed on the retina directly. In the studies of Green (1970[15]) and Enoch & Hope (1973[16]), there was close agreement of the interferometric and sinusoidal measurements up to only 2 degrees eccentricity. Thereafter they differed a great deal. Frisen & Glansholm (1975[17]) suggested that this might be due to experimental apparatus difficulties. However, from both experiments it was concluded that for eccentricities of about 8 degrees, under optimum viewing conditions, the visual acuity was not reduced proportionately to the degradation of the peripheral physiological optics. Green suggested that the fall in visual acuity must be associated with some property of the retina and/or visual pathways. In contrast, Frisen & Glansholm infered that interference fringes formed directly on the retina can be better resolved than external sinusoidal gratings. All of the above studies were carried out under cycloplegic near point conditions.

Millodot, Johnson, Lamont, & Leibowitz (1975[18]) and Kerr (1971[2]) proceeded to examine the relationship of peripheral acuity as measured by grating targets to Landolt C resolution. Weale (1956[19]) and Clarke & Belcher (1962[20]) both found that optical errors did not to a first approximation, account for the decrease in peripheral acuity. Millodot, et al. corrected the peripheral error. With sine gratings they found the most rapid drop occuring between 0 and 20 degrees eccentric. This is in good agreement with Kerr who did not correct the peripheral optics. Further testing conducted by Millodot, et al., using Landolt Cs for targets while correcting the peripheral optics, provided no appreciable improvement in peripheral acuity. Acuity diminished by a factor of 10 for the sine-wave grating and a factor of 15 for the Landolt C, however, the overall shape of the degradation curve was similar. In addition, both Millodot, et al. and Kerr examined the relationship of luminance on peripheral resolution. Both experimentors concluded that at lower photopic luminances the overall visual acuity was slightly reduced centrally and hardly effected towards the periphery. Therefore, one might agree from this evidence that the two fundamental variables, luminance and refractive error, which represent limiting factors in central vision are relatively unimportant for discrimination of detail in the peripheral visual field.

Due to the highly trainable characteristics of peripheral visual acuity, it was thought that the span ofrecognition could be increased by training the peripheral vision. Sailor (1973[21]) hypothesized that specific peripheral training would produce a significant increase in peripheral vision. Using two groups, one which received six weeks of peripheral visual training, the other receiving only reading enhancement training, showed a significant increase in peripheral vision for all subjects in both groups. They suggested that some other factor other than practice affected the expansion of the peripheral field. More research by Sailor & Ball (1975[22]) again noted a significant increase in peripheral vision in all subjects. Apparently, standard speed reading training (tachistiscopic training and rate increasers) increased peripheral vision even when specific peripheral vision training failed to do so. Of note was the fact that reading comprehension was unaffected by peripheral vision practice, however, reading speed was greatly improved on the post test.

A more specific application of visual acuity characteristics specifically related to reading was explored by Rayner (1975[23]). The purpose of the study was to ascertain to what degree a reader could acquire peripheral information under normal reading conditions and still be able to make a semantic interpretation of material read. Specifically a reader acquired information about word shape and specific letters (at an 18 minute of arc acuity level), no more than 12 to 15 character spaces or 4 degrees into the periphery at a distance of 53 centimeters. A semantic interpretation may only be made up to 2 degrees or 1 to 6 character spaces in temporal space. Beyond this the reader did not pick up enough information to interpret, most likely because of reduced acuity as well as visual interference or masking from other letters between the fixation point and the word in question. When two different pieces of information were being integrated in close time, the new stimulus pattern overrode or masked the pattern produced by the prior information. Rayner interprets that at a higher level of processing, both pieces of information are integrated, although previously masked. If visual or semantic discrepancies were introduced, as Rayner did, between the two successive pieces of information, this integration failed.

Although specific characteristics concerning the peripheral visual system have been investigated at great length in adults, there have been few investigations as to the performance of children. In a study conducted by Miller (1971[24]), school aged children viewed tachistiscopically presented Snellen letters requiring a localization response. The results failed to support the hypothesis that age differences in performance would find expression primarily in differences of localization of peripheral material.

Sparse publication of literature is available on school aged children's performance in peripheral visual acuity tasks. For that reason, the literature reported here is in reference to very young infant's response to peripherally presented lights of varying intensities. Aspinall (1976[7]) stated that children appeared to have constricted fields. He explained that the relative constriction might be related to a maturational defect of the visual system or the response system, or to a problem of attention, learning or motivation. Interestingly suggested was the possibility of cortical suppression of peripheral information existing to allow perceptual development in the foveal area. Also explained by Aspinall was the possibility that under certain experimental conditions the insensitivity of peripheral vision in children could be ascribed to response effects, while under other conditions, problems associated with general attention seemed most relevant. It was thought that the decline in children's peripheral detection was mainly due to the nature of the task and to factors which affect the response criterion in children rather than to differences in the visual mechanism itself.

MacFarlane, Harris & Barnes (1976[25]), testing infants 1 to 7 weeks old, attempted to examine the relationship between a competing central stimulus and the peripheral field. Apparently, a central stimulus narrowed the visual field, especially in older infants. It was suggested that an expansion of the effective visual field might permit a young infant to locate stationary objects and pursue moving objects with greater facility.

Whiteside (1976[8]) presented many relevant conclusions following his investigation with vatious peripheral luminances in 6 to 21 year olds. In previous experiments, eye movement was assumed to be a valid measure of peripheral response because one of the main functions of peripheral vision is to initiate and direct eye movements. Therefore, previous results suggested that peripheral sensitivity varied little with age, when eye movements were used as a response measure. If this assumption is made, the results say nothing about the ability to identify, recognize, and extract information from peripheral features. Peripheral sensitivity changes,then, could not account for age related improvements in organization and efficiency of visual scanning.

Problem

The present study was designed as an exploratory project to develop a technique using a dual target presentation for measuring peripheral visual acuity on school aged children. Two phases were required: first, to design and construct the equipment and secondly, to administer the test to grade school children to gain clinical experience. Administration of the test would allow preliminary calculations for determining how sensitive the test was to grade level, age, subtended angle, instructions, effect of paired stimuli and to evaluate the children's response mode.

METHOD

Subjects- Palo Christi Elementary School students of Kingman, Arizona District #4 were selected by their home room teachers as a representative group of all children grade levels 2, 4, and 6. A subject release form sent home to the parents is enclosed in Appendix A. Following temporal random withdrawl from classroom activities, there were 8 second graders, 11 fourth graders, and 9 sixth graders, for a total N or 28, who completed testing. As entire classes, each grade level was familiarized with the ability to see both of their hands without looking at them via a group demonstration.

Apparatus- The experimental apparatus consisted of two Kodak Caurosel slide projectors mounted vertically, one above the other, on angled lazy susans (Figure 1) to allow for the simultaneous projection of two Landolt Cs in the horizontal meridian (Figure 2).

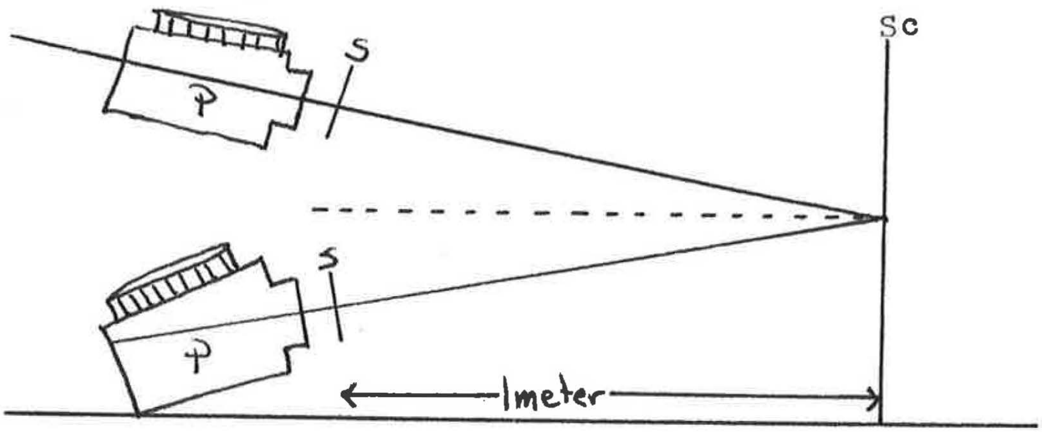


Figure 1: Schematic of slide projector (P) arrangement. S= electronic shutter. Distance between back projection screen (Sc) and slide projectors = 1 meter.

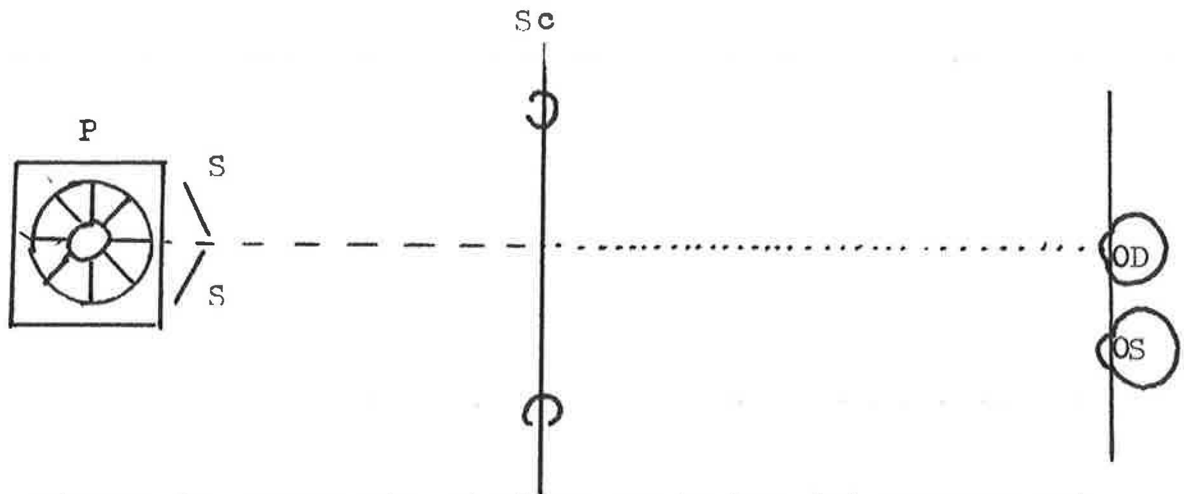


Figure 2: Schematic of slide projector (P) arrangement. S=electronic shutters. Sc=back projection screen. OD=right eye. OS=left eye. Slide projector to screen distance = 1 meter. Right eye to screen distance = 40 centimeters.

Time linked electronic shutters set to a duration of 200 milliseconds, to escape saccade latency, were attached to the 5 inch projection lenses. These shutters were triggered by a microswitch available to the experimentor. The stimulus display included a 45 centimeter wide back projection screen 40 centimeters away from a chin rest. Positive Landolt C's masked up to the exterior margin, preventing negative contour interaction, were presented simultaneously to both nasal and temporal fields of the right eye only. A 32 degree angular separation then extends 16 degrees into the nasal field and 16 degrees into the temporal field of the right eye only. It was hoped that this presentation would contribute additional controls for eye movement. In order for the subject to see both, it would be necessary to always view the small central dot. In addition, the experimentor kept visual watch of the subject's eye movements before triggering the microswitch.

Presentation of visual acuity levels were made at the 32 degree separation first, the 25 degree separation and lastly the 17 degree separation. The four acuity levels: 20/1300, 20/650, 20/325, and 20/162 were presented in random order at six orientations for 24 presentations at each of the three angular separations. Each presentation included a nasal and temporal field Landolt C at the same acuity level. The luminances of both Landolt Cs was 204 millilamberts as measured by the UB 1 1/2 Spectraphotometer with a 1.00 diopter close up lens at 27.5 inches. The color temperature of the nasal field target was 3400 degrees Kelvin, while the temporal field target measured 3450 degrees Kelvin, well within equal comparison.

Procedures- The left eye of each subject was occluded with an eye patch. Instructions to keep central fixation were given while the subject viewed the largest acuity level (20/1300) displayed on the screen. The subject was asked to report"which way the C went" beginning with the C on the side of the experimentor first. One demonstration of the time duration at which the stimulus would be presented was made. Thereafter, the 24 random acuity level presentations were made at each of the three angular separations beginning with the 32 degree angular separation first. Each set of

24 presentations took approximately seven minutes. Two to three minute rest periods were allowed after the 32 degree separation testing and after the 25 degree separation testing. The subject responded as chosen themselves, either with the hands or verbally.

RESULTS

Each childs' scores for the four acuity conditions and three angular separations were tabulated for each grade level. The results are displayed in Appendix B. The responses of the subjects were separated into both correct, represented by B; nasal only correct, represented by N; and temporal only correct, represented by T.

The .05 confidence level was selected to reject the null hypothesis for the student's t-test and the sign test which were used to test significance ($\alpha = .05$) throughout this study. If the difference was equal to or greater than the 1% level ($\alpha \leqq .01$) this was indicated.

It is of importance to understand that when the angular target separation of 32 degrees, 25 degrees, or 17 degrees is referred to, the actual acuity target fall one half of, say, 32 degrees or 16 degrees on the nasal retina or temporal field and 16 degrees on the temporal retina or nasal field.

The children's performance on the dual peripheral acuity targets was studied by comparing the second and sixth grade samples. Student's t-test was calculated for the 36 response conditions and no significant differences were observed between the second and fourth or fourth and sixth grades. As a result of finding no difference as a function of grade level, the data for the second grade (N=8), fourth grade (N=11), and sixth grade (N=9) were summed (Σ N=28). Table 1 displays the frequency distribution of the responses for all three grade levels by tabulating the number correct out of six orientations presented at each of the four acuity levels and three angular separations.

Table 2 contains the mean, standard deviation, and range for the totaled grade level responses at each acuity level and angular separation. Calculations were made from data shown in Table 1.

Graph 1a, 1b, 1c presents the combined data in mean percent correct for both correct, nasal only correct, and temporal only correct at each acuity level. Percent correct is plotted on the y-axis and visual acuity is plotted on the x-axis.

The frequency of correct responses for each angular separation (32, 25, and 17 degrees) at each of the four acuity levels was compared by response category of both correct, nasal only correct, or temporal only correct. The comparison was done by calculating the student's t-test for each set.

Table 1

		32°			25°			17°		
		B	N	T	B	N	T	B	N	T
20/1300	6/6	21	23	7	25	23	16	25	24	17
	5/6	6	2	15	2	5	9	3	2	10
	4/6	1	2	5	-	-	2	-	2	-
	3/6	-	-	1	1	-	1	-	-	1
	2/6	-	1	-	-	-	-	-	-	-
	1/6	-	-	-	-	-	-	-	-	-
	0/6	-	-	-	-	-	-	-	-	-
20/650	6/6	22	20	2	20	18	10	22	22	11
	5/6	4	6	11	6	7	14	5	4	14
	4/6	1	-	4	1	1	2	1	1	1
	3/6	-	-	7	1	1	1	-	1	1
	2/6	1	1	2	-	1	1	-	-	1
	1/6	-	1	1	-	-	-	-	-	-
	0/6	-	-	1	-	-	-	-	-	-
20/325	6/6	12	13	4	12	15	6	22	21	7
	5/6	9	10	7	9	7	7	5	7	4
	4/6	5	3	1	6	5	7	1	-	7
	3/6	2	-	8	1	1	4	-	-	8
	2/6	-	2	5	-	-	2	-	-	2
	1/6	-	-	2	-	-	2	-	-	-
	0/6	-	-	1	-	-	-	-	-	-
20/162	6/6	5	16	6	5	11	4	15	1	1
	5/6	5	5	3	11	6	10	10	10	10
	4/6	7	7	11	6	9	5	3	8	8
	3/6	7	-	3	5	1	5	-	7	7
	2/6	4	-	2	1	1	4	-	1	1
	1/6	-	-	3	-	-	-	-	1	1
	0/6	-	-	-	-	-	-	-	-	-

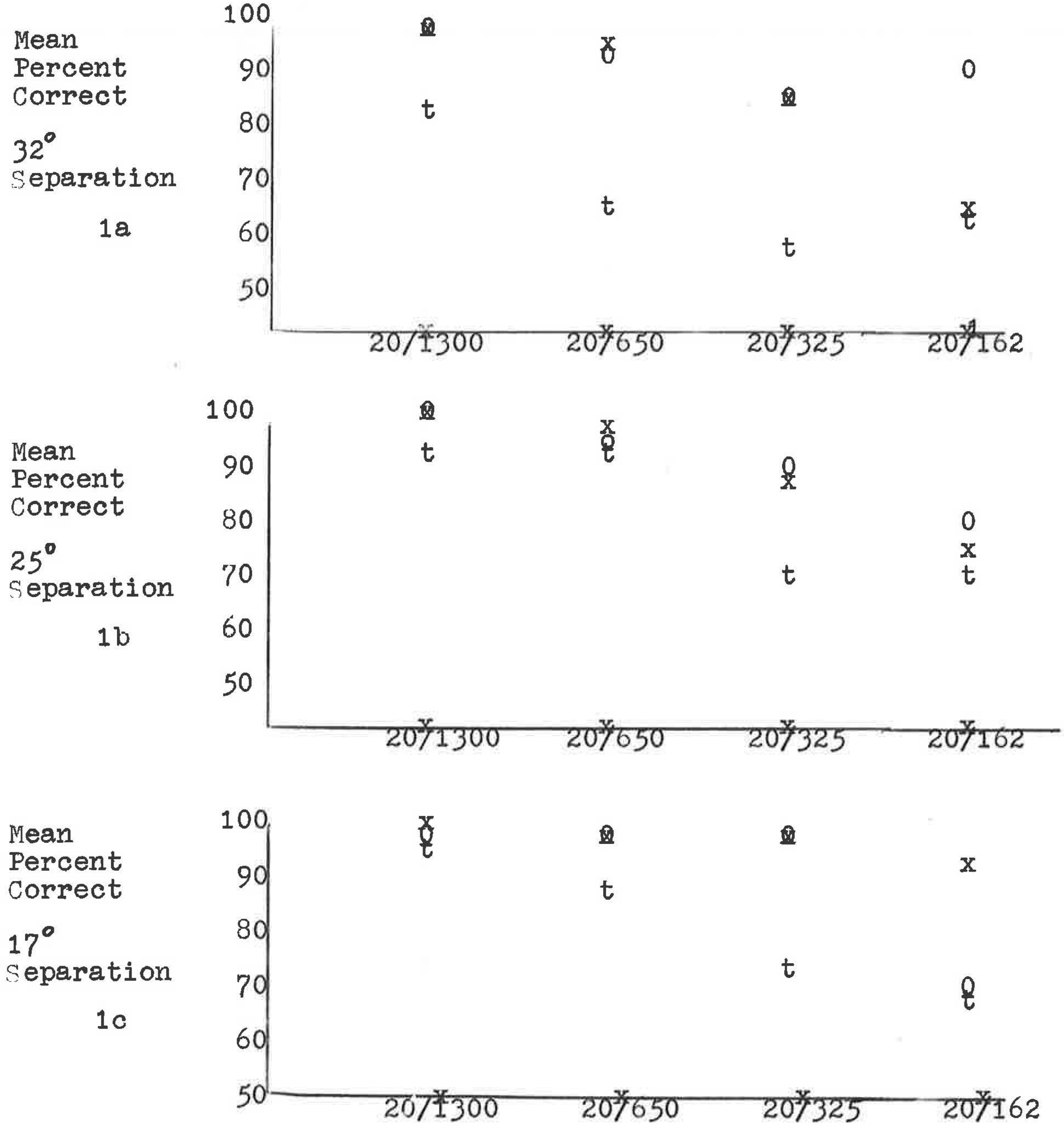
Table 1: Frequency distribution of the number correct for number tried for the combined population at each acuity level and angular separation. B=both correct. N=nasal only correct. T=temporal only correct.

Table 2

		32° Mean/std. dev./ range	25° Mean/std.dev./ range	17° Mean/std.dev. range
20/1300	B	5.71/0.52/4-6	5.82/0.60/3-6	5.89/0.31/5-6
	N	5.64/0.90/2-6	5.82/0.38/5-6	5.79/0.56/4-6
	T	5.00/0.76/3-6	5.43/0.78/3-6	5.54/0.68/3-6
20/650	B	5.64/0.85/2-6	5.61/0.72/3-6	5.75/0.51/4-6
	N	5.46/1.18/1-6	5.43/0.98/2-6	5.68/0.71/3-6
	T	3.89/1.45/0-6	5.11/0.94/2-6	5.18/0.93/2-6
20/325	B	5.11/0.94/3-6	5.14/0.8748/3-6	5.75/0.51/4-6
	N	5.14/1.09/2-6	5.29/0.88/3-6	5.75/0.43/5-6
	T	3.54/1.68/0-6	4.18/1.47/1-6	4.21/1.29/2-6
20/162	B	4.00/1.31/2-6	4.50/1.09/2-6	5.43/0.68/4-6
	N	5.32/0.85/4-6	4.89/1.08/2-6	4.00/1.10/1-6
	T	3.96/1.52/1-6	4.18/1.28/2-6	4.00/1.10/1-6

Table 2: Mean, standard deviation, and range for the combined data at each acuity level and angular separation. B=both correct. N=nasal only correct. T=temporal only correct. Std.dev.=standard deviation.

Graph 1a,1b,1c



Graph 1a,1b,1c: Combined data in mean percent for both correct, represented by (x), nasal only correct, represented by (0), and temporal only correct, represented by (t) at each of the four acuity levels. Percent correct for each angular separation is plotted on the y-axis and visual acuity is plotted on the x-axis.

These results are summarized in Table 3, where significance is indicated by S, and not significant is indicated by NS. At the 20/1300 acuity level there was no significant difference between any angular separation when both or nasal only responses were analyzed. There was a significant difference in response at all three angular separations when only the temporal target was reported correctly. At the 20/650 acuity level, again there was no significant difference when the both or nasal only stimuli were reported correctly. There was a significant difference between all three angular separations when only the temporal target was reported correctly. At the 20/325 acuity level, a significant difference was demonstrated between the 32 and 17 degree separation, but not the 32 and 25 degree separation, when the both or nasal only targets were reported correctly. The temporal only response at this acuity level was not significantly different at any angular separation tested. At the 20/162 acuity level, there was a significant difference between the 32 and 17 degree separation but not the 32 and 25 degree separation when the both or nasal only targets were reported correctly. The temporal only response was not significantly different at any angular separation. Eight significant results out of 24 comparisons is greater than chance variation. Several variables probably contribute to this result and can not be differentiated based on the data from this study.

Table 3

20/1300	B	NS		NS	
	N	NS		NS	
	T	S	17° > 32°	S	25° > 32°
20/650	B	NS		NS	
	N	NS		NS	
	T	S	17° > 32°	S	25° > 32°
20/325	B	S	17° > 32°	NS	
	N	S	17° > 32°	NS	
	T	NS		NS	
20/162	B	S	17° > 32°	NS	
	N	S	32° > 17°	NS	
	T	NS		NS	

Table 3: Results of t-tests at .05 confidence level when comparing the significance of mean correct responses over the three angular separations. S=sinificant. NS=not significant. B=both correct, N=nasal only correct, T=temporal only correct. Direction of difference for each significant t-test is indicated thusly: Angular separation of greatest mean number correct> Angular separation of least mean number correct. N=28.

By inspection of Graph 1a,1b,and 1c, an observable difference in response to either nasal only or temporal only stimuli is evident. The data were analyzed by a sign test. These are summarized in Table 4. At the 20/1300, 20/650, 20/325 and 20/162 acuity levels, there was a significant difference at the .05 confidence level for the 32, 25, and 17 degree separations. The nasal field target of the two acuity targets presented in each stimulus field was selectively responded to when only one of the two targets was reported correctly. Correct response to the target to the child's left were over four times more frequent than responses to the child's right ($p \leq .01$).

Individual observations of the children's behavior while performing the required orientation identification task are of interest to note here. The testing was carried out over a week's period at the elementary school. The sixth graders were first. Their responses were usually verbal. During the decision making process following the stimulus presentation, there was a great deal of motor overflow including facial contortions and body movement. The time necessary to verbally make a response was sometimes quite lengthy. Many times the sixth graders corrected their report of left or right. As the week continued the grade level decreased until the second graders were tested. The second graders seemed more assured of their responses, which

Table 4

		32°	25°	17°
20/1300				
	N=28			
	Ties	5	14	15
	N < T	4	3	3
	N > T	19	11	10
		$p \leq .01$	$p \leq .05$	$p \leq .05$
20/650				
	N=28			
	Ties	5	13	14
	N < T	2	3	2
	N > T	21	12	12
		$p \leq .01$	$p \leq .05$	$p \leq .01$
20/325				
	N=28			
	Ties	5	4	6
	N < T	5	6	2
	N > T	18	18	20
		$p \leq .01$	$p \leq .05$	$p \leq .01$
20/162				
	N=28			
	Ties	8	5	1
	N < T	4	7	6
	N > T	16	16	21
		$p \leq .01$	$p \leq .05$	$p \leq .01$

Table 4: Sign test comparing nasal only responses to temporal only responses. Confidence level is .05 and .01. Total number of subjects is indicated by N=28 in each row. Ties represents the number of times the number correct for the nasal only response equaled the number correct for the temporal only response. N > T indicates the number of times the nasal only response was greater than the temporal only response. N < T indicates the number of times the nasal only response was less than temporal only response.

they usually made with motions of the hands and body. The more assured the child was of the response, the more enthusiastic and quicker was the report. At no time during the testing was the child required to ellicit the response in any set manner. They were simply asked which was the two C's were pointing and allowed to signify any was they chose. Considering the complexity of the dual target presentations the second graders were very capable of comprehending the task and responding with ease.

SUMMARY AND DISCUSSION OF RESULTS

The original premise from which the present study was defined was to study peripheral visual acuity thresholds in school aged children. Due to experimentor error the original 20/400, 20/200, 20/100, and 20/50 acuity levels were surpassed when administering the test in Arizona. This was not discovered until the investigator returned from externship at St. Louis Optometric Center. According to Low (1951[1]) and Lind and Larsen (1954[26]) one would expect that at 8 degrees of eccentricity in the temporal field, acuity would range from 20/50 to 20/180. At 12 degrees of eccentricity, acuity would range from 20/80 to 20/200. At 16 degrees of eccentricity, acuity would range from 20/100 to 20/300. The most demanding acuity level in the present study, of 20/162, could be obtained at any of three angular separations tested.

Due to the lack of presentation of a threshold acuity target, it is difficult to conclude that the results of comparing the angular separations were significant. Of note in those comparisons of Table 3 was the similarity of the 20/1300 responses to the 20/650 responses and also the similarity of the 20/325 responses to the 20/162 responses. Eight significant results out of 24 comparisons is greater than chance. The similarity of the results is somewhat perplexing. It might be possible that if the angular separation were increased, the entire second column might become significant. This is pure conjecture and an enigma beyond the scope of the present investigation.

Since the present study was exploratory in nature, the sample size of N=8, N=11, and N=9 is much too small to assume that there was no significant difference attributable to grade level. Larger samples would be needed to settle the question. If dual target presentation is continued in future studies, a population of adults is suggested to test the reliability of the test design before testing children.

The ability of the children to identify Landolt C orientation when dual targets were presented is interesting. Eye movements were controlled for by shutter presentation of less than saccade latency and the visual observation of the experimentor before engaging the microswitch for display of the stimuli. Additionally, the actual dual target presentation was used to control for eye movements. Right eyes only were tested in each child to keep training effects to a minimum. A correct response to both targets was found as frequently as a correct response to the subject's left or nasal field target. When only one target of the pair was reported correctly the nasal field target was identified correctly more often than the temporal field by a ratio in excess of 4 to 1. This ratio held for all acuity sizes at the three sets of angular separation. As only the right eye was tested, one can not assume that this response was due to the cultural effects of learning to read from left to right. The conclusion that the response is due to physiological superiority of the temporal retina is also not valid.

This exploratory study demonstrates that a dual target peripheral acuity test is feasible for continued development for school aged children. A trend was found for increased recognition error with each decreasing acuity size with increasing angular subtense. Since three of the four acuity targets were 4 times threshold measured for young adults, it is reasonable to assume that the effect would be more marked with smaller angular sizes at each subtended angle.

Suggestions for Future Research

Above all other conclusions reached in the present study, that which lends itself to further investigation is the tendency to respond correctly to the nasal field stimuli when responding to the dual target stimulus. In the future, it is suggested that this method of presentation of peripheral acuity targets should include acuity sizes which stradle the thresholds more closely. As stated previously, these design suggestions should be carried out on adults before testing children to standardize results.

Certain limitations were encountered when dealing with photogrphic resolution. A film size Landolt C of 1 millimeter total diameter was the smallest measureable photograph feasible. Additional diminution of acuity size and increased angular separation could be obtained with a larger back projection screen. The flexible back projection screens available from certain science catalogs have excellent resolution.

It is further suggested that a more practical display with both acuity targets could be arranged on a Keystone Overhead Projector. This would allow simultaneous projection of acuity targets without the problems of cross projection systems.

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APPENDIX B

Second Grade		32°				25°				17°			
		1300	650	325	162	1300	650	325	162	1300	650	325	162
#1	B	6	6	4	3	6	6	6	6	6	6	6	5
	N	6	6	5	5	6	6	6	3	6	6	5	5
	T	4	0	5	5	6	6	5	6	5	6	4	4
#2	B	6	6	5	6	6	5	4	6	6	6	6	6
	N	6	6	5	4	6	5	5	4	6	6	5	4
	T	4	5	3	4	5	6	5	5	6	6	4	5
#3	B	6	5	6	2	6	6	5	5	6	6	6	6
	N	5	6	6	6	6	6	5	4	6	6	6	6
	T	5	5	2	5	6	3	4	6	6	5	2	5
#4	B	6	6	6	5	6	6	6	4	6	5	6	4
	N	6	6	6	4	6	5	6	6	6	5	6	6
	T	5	5	3	4	3	4	2	2	6	5	2	4
#5	B	5	6	6	3	6	5	4	5	6	6	6	5
	N	6	6	6	6	5	4	6	4	6	6	6	6
	T	5	2	3	6	6	5	4	4	5	4	5	5
#6	B	6	6	5	4	6	6	4	3	6	5	5	6
	N	6	6	5	5	6	5	4	6	6	6	6	6
	T	5	4	3	6	5	5	5	5	6	6	3	3
#7	B	6	6	5	4	6	6	6	5	5	5	5	5
	N	6	5	5	6	6	5	5	6	5	3	5	4
	T	5	3	3	2	6	5	1	5	6	5	6	5
#8	B	6	6	6	2	6	6	6	5	6	6	6	5
	N	6	6	6	5	6	6	6	5	6	6	6	5
	T	5	2	2	5	6	2	3	4	5	3	5	3

Response distribution for each individual indicated by #1,etc. Frequencies shown are number correct out of six for each acuity level and angular separation. For instance 6 out of 6 correct is represented by a 6.B=both correct.N=nasal only correct. T=temporal only correct.

APPENDIX B-continued

Fourth Grade N=11		32°				25°				17°			
		1300	650	325	162	1300	650	325	162	1300	650	325	162
#1	B	4	6	3	5	6	6	5	4	6	6	6	4
	N	6	6	4	6	6	6	6	4	6	6	6	4
	T	4	1	6	1	6	6	4	4	5	5	4	5
#2	B	6	5	5	4	3	3	5	4	5	3	5	6
	N	4	5	6	6	5	5	4	6	6	6	6	5
	T	5	5	2	4	5	5	5	2	5	5	3	4
#3	B	6	4	5	3	6	5	6	6	6	6	6	5
	N	6	5	4	6	6	6	6	4	6	6	6	6
	T	6	5	5	4	5	6	3	3	5	5	4	3
#4	B	6	5	5	5	6	6	6	4	6	6	6	5
	N	6	6	6	6	6	6	6	6	5	6	6	5
	T	6	4	0	2	6	5	3	2	3	6	4	4
#5	B	5	6	6	3	6	6	6	6	6	6	6	6
	N	6	6	5	6	6	6	6	5	6	6	6	4
	T	5	3	5	4	6	6	5	5	6	6	6	5
#6	B	6	6	4	6	6	6	5	4	6	6	6	6
	N	6	6	4	4	6	6	5	2	6	6	6	5
	T	5	4	6	4	5	5	6	5	6	6	6	5
#7	B	6	6	4	4	6	5	5	5	6	6	6	5
	N	6	6	6	6	6	6	6	6	6	6	5	6
	T	4	3	2	3	6	5	3	3	6	5	5	3
#8	B	5	6	4	5	6	6	6	4	6	6	6	6
	N	4	1	5	4	5	3	4	6	6	6	6	4
	T	6	6	5	4	6	6	6	4	6	6	6	5
#9	B	6	6	5	3	6	6	6	5	6	6	5	6
	N	5	6	6	6	6	6	6	5	4	6	6	6
	T	6	4	1	4	6	5	1	3	5	5	3	1
#10	B	5	6	4	3	6	6	4	3	6	6	6	6
	N	2	2	2	4	5	2	5	5	6	4	5	2
	T	6	5	6	6	4	5	4	5	6	6	4	5
#11	B	6	6	5	4	6	6	6	5	6	6	6	6
	N	6	6	6	5	6	6	5	5	6	6	6	3
	T	3	3	3	3	6	6	5	3	6	6	6	6

APPENDIX B-continued

Sixth Grade N=9		32°				25°				17°			
		1300	650	325	162	1300	650	325	162	1300	650	325	162
#1	B	6	5	6	6	6	5	4	6	6	6	6	6
	N	6	6	5	6	6	6	6	4	6	5	5	6
	T	5	6	5	1	5	6	6	3	6	5	4	4
#2	B	5	6	6	3	5	5	5	5	6	5	6	4
	N	6	5	5	6	5	6	4	4	6	5	6	5
	T	5	5	1	4	6	6	6	6	6	5	2	4
#3	B	6	6	6	6	6	6	5	5	6	6	6	6
	N	6	5	5	6	6	6	6	6	6	6	6	6
	T	4	5	5	1	6	6	5	2	6	5	3	3
#4	B	6	6	5	4	6	6	5	5	6	6	5	6
	N	6	5	6	6	6	6	5	6	4	6	6	4
	T	6	3	3	4	6	5	4	5	6	2	3	3
#5	B	6	6	6	4	6	6	6	5	6	6	6	5
	N	6	6	5	6	6	6	6	6	6	6	6	6
	T	5	3	2	4	5	5	4	6	5	6	3	2
#6	B	6	6	6	5	6	6	4	2	6	6	6	5
	N	6	6	6	5	6	6	4	6	6	5	5	5
	T	5	3	3	6	5	5	6	5	6	5	6	5
#7	B	5	2	3	2	5	4	6	3	5	5	4	5
	N	6	6	6	6	6	6	3	5	6	6	6	6
	T	5	5	5	6	5	5	2	4	6	6	6	4
#8	B	6	6	6	5	6	6	3	3	6	6	6	6
	N	6	6	2	4	6	5	6	4	6	6	6	6
	T	6	5	6	6	6	4	6	5	5	5	3	3
#9	B	6	6	6	6	6	6	5	3	6	6	6	6
	N	6	6	6	4	6	5	6	4	6	6	6	6
	T	5	5	4	3	4	5	4	5	5	5	5	4